SPECIFICATION AMENDMENTS

Page 1, replace the paragraph beginning at line 1 with:

This disclosure is a division of U.S. Patent Application 10/045,019, filed April 15, 2002.

Amendments to the paragraph beginning at page 3, line 7:

However, the resistance to the rotation of the steering wheel also resists the rotation of the steering wheel as it returns to its neutral position, and this could cause a substantial discomfort to the vehicle operator. However, since this technique controls the rotational resistance which is added to the steering system according to, for example, a road surface friction coefficient, the resistance is also added to the~~ returning~~ operation of returning the steering wheel to its neutral position.

Amendments to the paragraph beginning at page 3, line 19:

However, since this technique controls an output torque of the electric motor to reduce an assisting force by the electric motor to increase a steering reaction force as the steering angle of the manual steering system approaches the limit steering angle (maximum permissible steering angle value), the vehicle operator experiences difficulty in getting a feeling of a slippery road surface and, further, tends to excessively cut the steering wheel on the slippery road surface. Moreover, although it is necessary to detect a friction coefficient of a road surface, left and right road wheels often have different friction coefficients of a road surface, for example, in a case where snow remains only on shoulders of the road. In addition, it is difficult to accurately detect a friction coefficient of a road surface because it changes every moment.

Replace the paragraph beginning at page 7, line 3 with:

~~In the~~The electric power steering controller according~~ to claim 1,~~ the invention further~~ comprising~~ comprises a quantity of state sensor for detecting a quantity of state of any one of a yaw rate, a lateral acceleration and a side slip angle of a vehicle, the reaction

force torque detecting unit is a road surface reaction force torque detecting unit for detecting a reaction force torque of a road surface on which a vehicle runs, the superimposed reaction force torque calculating unit multiplies a quantity of state of any one of a yaw rate, a lateral acceleration and a side slip angle of a vehicle detected by the quantity of state sensor by a gain to calculate a superimposed reaction force torque in the return direction of a steering wheel, and the control unit controls the gain such that the superimposed reaction force torque is reduced when the road surface reaction force torque is large and the superimposed reaction force torque is increased when the road surface reaction force torque is small.

Replace the paragraph beginning at page 12, line 9 with:

In addition, the steering shaft reaction force torque Ttran is a sum of a road surface reaction force torque Talign representing a reaction force from a road surface on which a vehicle runs and a frictional torque ~~Tfric~~ <u>Tfrp</u> inside a steering mechanism. The road surface reaction force torque is the smallest when the vehicle moves straight forward. It increases in proportion to a steering wheel angle until the steering wheel becomes a predetermined angle and, after the steering wheel angle exceeds the predetermined angle, gradually decreases as the steering wheel angle increases. On the other hand, the frictional torque is constant in magnitude and has a characteristic that its sign changes depending on ~~a~~ <u>the</u> direction in which the steering wheel is turned. Therefore, the steering shaft reaction force torque in turning the steering wheel increases when the steering wheel is turned and decreases when the steering wheel is returned even if the steering angle is the same.

Replace the paragraph beginning at page 13, line 1 with:

The ECU 111 calculates a target value of current supplied to the electric motor 105 (motor current target value) from <u>each of</u> the ~~above-mentioned each~~ sensor ~~signal~~ <u>signals</u> and controls current such that an actual current flowing through the electric motor 105 coincides with this motor current target value. Consequently, the electric motor 105 generates a predetermined torque that is found by multiplying the current value Imtr by the torque constant Kt and the gear ratio Ggear and assists a torque generated by steering of a vehicle operator.

Replace the paragraph beginning at page 13, line 12 with:

As shown in Fig. 2, the ECU 111 is provided with a steering torque controller 121, a return torque compensator 123, a damping compensator 125, an inertia compensator 127, a vehicle speed detector 129 in which a vehicle speed signal from a not-shown vehicle speed sensor is ~~inputted~~ input to detect ~~a~~ vehicle speed, a steering torque detector 131 in which a steering torque signal from the torque sensor 103 is ~~inputted~~ input, a steering shaft reaction force torque detector 133 ~~in~~ into which a steering shaft reaction force torque signal is ~~inputted~~ input, a steering wheel angle detector 135 ~~in~~ into which a steering wheel angle from the steering wheel sensor 107 (rotational angle from a steering wheel neutral position) is ~~inputted, a~~ input. A motor speed detector 137 ~~in~~ into which a voltage detection signal and a current detection signal are ~~inputted~~ input from the electric motor 105 to detect ~~a~~ rotating speed of the electric motor 105 and a motor acceleration detector 139 for calculating ~~a~~ rotational acceleration of the electric motor 105 from an output of the motor speed detector 137. Vehicle speed detection signals are ~~inputted in~~ input into these controllers and compensators and control parameters are changed based on the ~~inputted~~ input vehicle speed detection signals. In addition, an output of the steering torque controller 121 is ~~inputted in~~ input to an adder 141, in which outputs of the return torque compensator 123, the damping compensator 125, and the inertia compensator 127 are added to the output of the steering torque controller 121 to calculate a current target value. This current target value is ~~inputted in~~ input to a subtractor 143, where an output (motor current value) of a motor current detector 147 for detecting a current flowing through the electric motor 105 is subtracted from the current target value ~~and the~~. The difference ~~of~~ between the values is ~~inputted in~~ input to a motor driver 145. The motor driver 145 controls ~~a supply~~ current supplied to the electric motor 105 based on an output signal from the subtractor 143. Here, since a new element is the return torque compensator 123 in the present invention, the return torque compensator 123 will be hereinafter described in detail.

Replace the paragraph beginning at page 14, line 14 with:

Operations of the return torque compensator 123 ~~will be hereinafter~~ are described based on ~~a~~ the flow chart of Fig. 3. First, a detected steering torque Thdl is read in and stored in a memory (step S1), a motor speed signal is read in and stored in the memory (step S2), a steering shaft reaction force torque is read in and stored in the memory (step

S3), and a steering angle θhdl is read in and stored in the memory (step S4). Subsequently, the motor speed signal is differentiated to calculate a motor acceleration signal (step S5), a basic target current Ibase is calculated based on the steering torque Thdl (step S6), a damping current Idamp is calculated (step S7) and an inertia compensating current Iiner is calculated (step S8). Next, a steering angle ~~F/B~~ feedback (F/B) gain is determined according to a ~~map chart~~ graph (a ~~relation chart on a~~ relationship between steering shaft reaction force torque and ~~a~~ F/B gain) as shown in Fig. 4 from a steering shaft reaction force torque (step S9). The steering angle F/B gain is small when a steering wheel is turned and is large when the steering wheel is returned. The steering angle θhdl is multiplied by the steering angle F/B gain ~~by~~, based on the steering shaft reaction force torque, to find a steering wheel return current Itire (step S10). The steering wheel return current Itire is added to the basic target current Ibase to calculate a target current Iref (step S11). ~~The~~ Since the steering wheel return current Itire ~~acts~~ is added to the basic target current Ibase, i.e., is superimposed on the basic target current, the steering wheel return current functions as a superimposed reaction force torque.

Replace the paragraph beginning at page 15, line 8 with:

According to this first embodiment, ~~a~~ the F/B gain for calculating ~~a~~ the superimposed reaction force torque is ~~made~~ a variable that varies with the steering angle, ~~whereby it becomes possible to reduce~~ so that the superimposed reaction force torque decreases when the steering shaft reaction force torque ~~is~~ becomes relative large and ~~increase the superimposed reaction force torque~~ increases when the steering shaft reaction force torque ~~is~~ becomes small. Thus, as shown in Fig. 5A, ~~a~~ the return ~~amount~~ of a steering wheel ~~can be~~ is improved ~~without making~~ so that a driver maintains a proper feeling of steering at the end of turning of the wheel and return of the wheel to the neutral position. This result is achieved by ensuring that the steering shaft reaction force, after compensation~~, to which the~~ by adding a superimposed reaction force torque calculated using a variable F/B gain, is ~~added, unnecessarily~~ prevented from becoming large, as compared ~~with the case in which~~ to calculating a compensating reaction force torque based upon a constant gain ~~is constant~~ (Fig. 5B). In addition, on a slippery road surface, if ~~a~~ the F/B gain is constant, ~~fall of~~ a reduction in the road surface reaction force is ~~hard~~ difficult to ~~be seen~~ detect when the steering wheel is gradually turned (Fig. 6B). However, since a vehicle operator can easily sense a slippery ~~feeling by making a~~ road when the F/B gain ~~for~~ used in calculating ~~a~~ torque ~~in~~ that varies with the steering ~~wheel~~

~~return direction variable~~ angle (Fig. 6A), the tendency of the vehicle operator to excessively steer the vehicle on a slippery road can be prevented.

Replace the paragraph beginning at page 28, line 1 with:

This eighth embodiment is completely the same as the above-mentioned third embodiment except that a steering shaft reaction force torque is estimated using an output of the motor acceleration detector 139 in addition to an output of the steering torque detector 131 and an output of the motor current detector 147 and that a road surface reaction force torque is estimated from a steering shaft reaction force torque and a gain is changed according to an output of the steering shaft reaction force torque detector 133. The other principles and effects are completely the same as those of th~~e section of the effects according to claim 6~~ third embodiment.